2000–2001 Drought Report: Executive Summary

INTRODUCTION

The 2000–2001 drought in Central and South Florida was a significant hydrologic and water management event. During this period, all water users experienced a critical water supply shortage. The continual monthly rainfall deficit compounded the decline in storage volume, forcing the South Florida Water Management District (District or SFWMD) to declare a drought emergency and implement water use restrictions. Daily, weekly, and monthly drought reports were generated to assist water management decision making and inform the public about the status of the system. The District took the lead in facilitating a multi-agency response to this event, coordinating a series of decisions and actions to protect the public interest.

Historical droughts and water shortages have been marked by (1) declines in lakes, reservoirs, and groundwater levels, (2) declines in rainfall and runoff, and (3) increases in the number and magnitude of wildfires. In Central and South Florida, severe droughts were reported in 1932, 1955–1957, 1961–1963, 1971–1972, 1973–1974, 1980–1982, 1985, 1988–1989, 1990, and 2000–2001. Drought impacts have been measured in loss of agricultural products, inadequate public water supply, loss of soil by wind erosion and subsidence, saltwater intrusion into freshwater aquifers, fires, other economic losses associated with water use, and ecological effects.

The District is divided into four planning areas within which water supply planning and other activities are focused: the Lower East Coast (LEC), Lower West Coast (LWC), Upper East Coast (UEC), and the Kissimmee Basin. This summary provides an overview on the effects of the 2000–2001 drought on water levels, flow, storage, groundwater levels, system operations, water demand and supply management, and environmental impacts for each of these regions. It also provides drought information for Lake Okeechobee, Lake Kissimmee, Lake Istokpoga and the Indian Prairie Basin, the Kissimmee River Basin, the Water Conservation Areas (WCAs) and the Stormwater Treatment Areas (STAs). The summary presents a chronology associated with water use restrictions and water demand management and describes the role emergency management and communications played in the District's response to drought. This information highlights the economic impacts of the drought and discusses the lessons learned and recommendations stemming from the District's experience with related issues. The Executive Summary and Parts I and II of the complete drought report are available on the District's website at http://www.sfwmd.gov/org/ema/reports/drought_report_2001/index.htm and are also available on CD-ROM upon request.

DROUGHT SEVERITY

The Palmer Drought Severity Index is used to monitor drought conditions occurring over several months. The index uses moisture conditions, precipitation, temperature, field capacity, and weather trends to compute an index value. Near normal conditions are represented by an index value between 0 ±0.49; severe droughts have an index value of -3.0 or less. **Figure 1** shows the index values for the five climatic divisions covering the District at the onset of the most recent drought through September 2001.

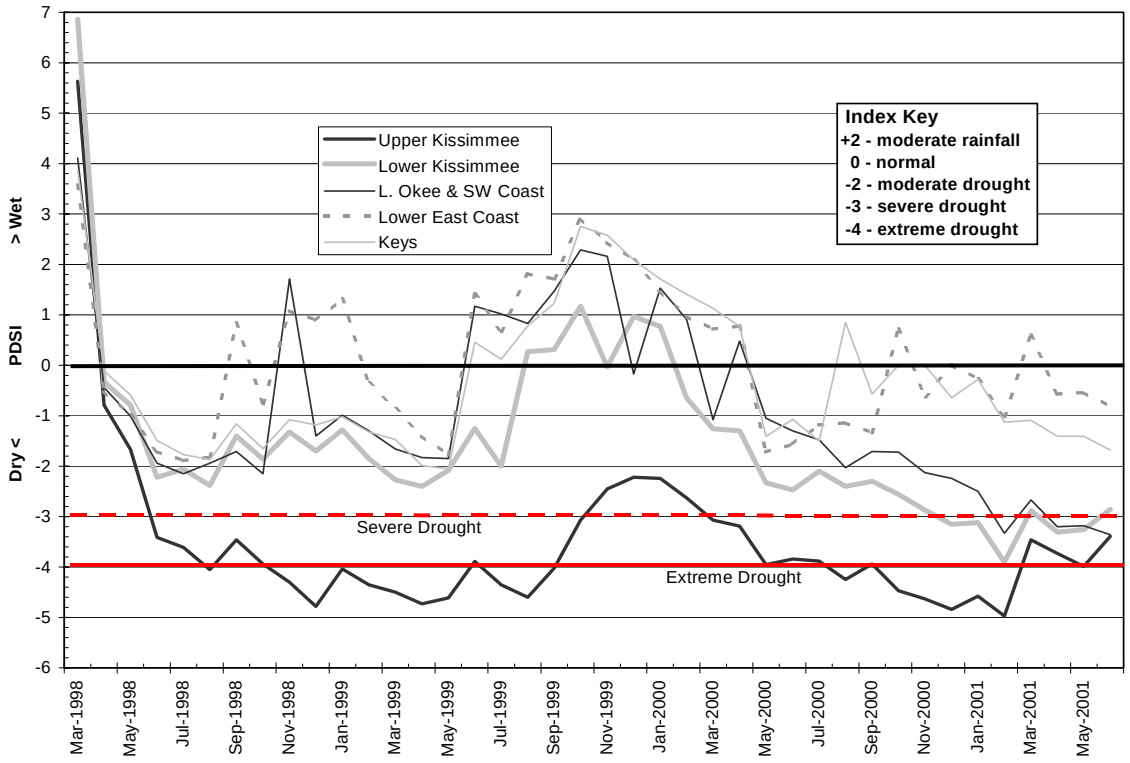

Figure 1. Palmer Drought Severity Index - Florida climatic divisions 3, 4, 5, 6, and 7 (March 1998–September 2001)

RAINFALL

The District receives a high amount of rainfall, caused by frontal, convective, and tropical weather systems. Typically, the wet season lasts from June through October and accounts for 66 percent of annual rainfall; the dry season lasts from November to May. Runoff from rainfall events is stored in ponds, lakes, impoundments, and aquifers and each reflects drought conditions. Excess water is discharged to the ocean to control flooding. Critical decision making is required to manage flooding or avoid potential water shortages. In this subtropical environment, both water shortage and flooding have the potential to occur in any month of the year.

Early indications of the drought can be traced back to November 1999, the beginning of the dry season. Rainfall during the dry season (November to May) was below expected values in 2000 and 2001 (**Figure 2**). During the 2000 wet season (June to October), rainfall was below expected amounts for all rainfall areas, except Miami-Dade (**Figure 3**). Most areas in the northern part of the District experienced monthly deficits throughout the period starting November 1999. The Broward, Miami-Dade, WCA-1, and WCA-2 rainfall areas were relatively less affected by the drought. The Upper Kissimmee, Lower Kissimmee, and Lake Okeechobee watersheds contribute most of the inflows to Lake Okeechobee. The 2000 annual rainfall for these three areas

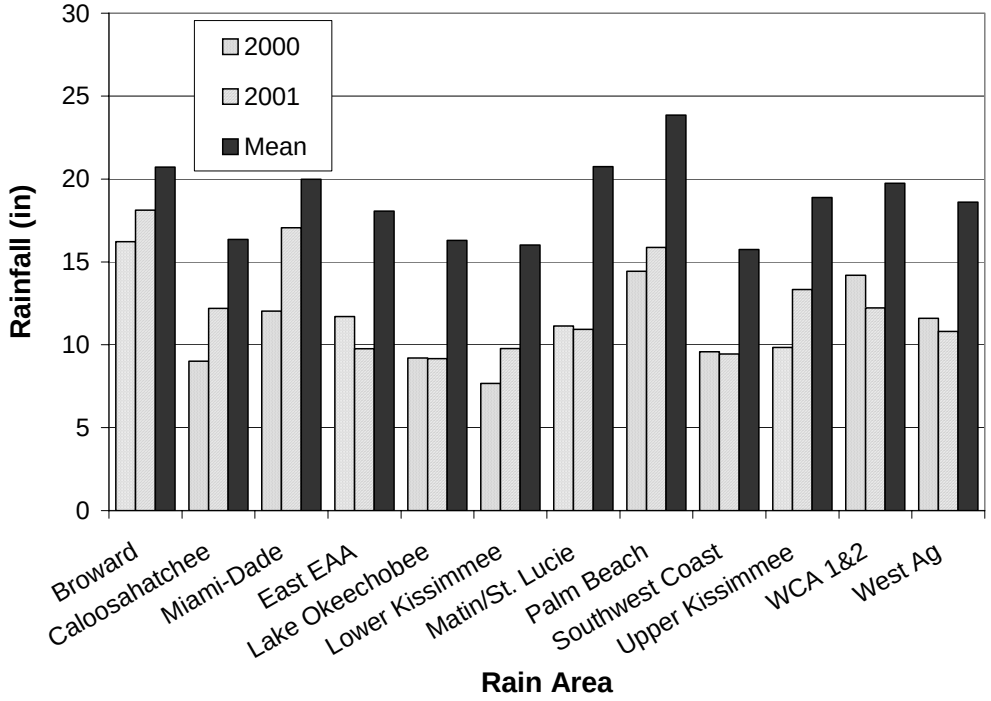

Figure 2. Dry season observed rainfall versus mean rainfall by rain area during 2000–2001

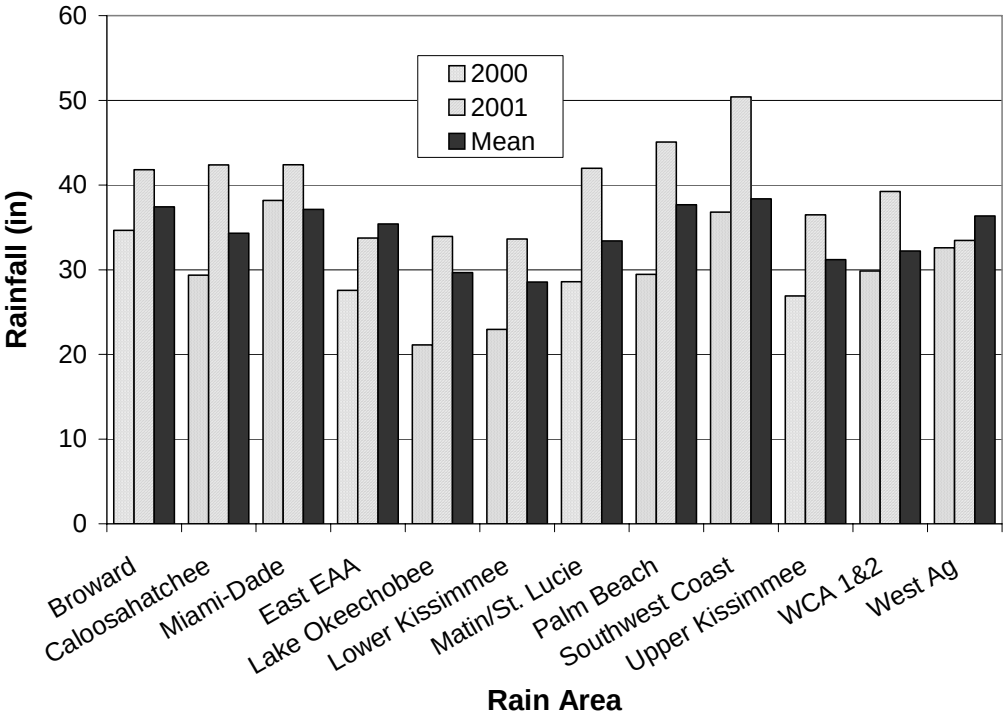

Figure 3. Wet season observed rainfall versus mean rainfall by rain area during 2000–2001

was very low with a dry frequency of 1 in 100 years and an average annual deficit of 35 percent below normal. The 2000 annual District-wide rainfall deficit was 25 percent of the historical average.

The drought persisted in most areas through August 2001. For the first eight months of 2001, the East EAA and West Ag rainfall areas had a severe rainfall deficit compared to the historical average for the same period. Hurricane Gabrielle passed through Central Florida in the middle of September 2001. This hurricane and the associated tropical system resulted in significant rainfall over a large area, contributing to drought relief.

IMPACTS AND RESOURCE MANAGEMENT

KISSIMMEE BASIN

The Kissimmee Basin planning area covers approximately 3,500 square miles and includes parts of Orange, Osceola, Polk, Highlands, Okeechobee, and Glades counties. This area was severely affected by the drought. From October 1, 1999 to September 30, 2001, Lake Kissimmee fluctuated between 52.6 and 48.3 feet National Geodetic Vertical Datum (ft NGVD), with the minimum level occurring on April 29, 2001.

Based on flow data from January 1, 1972 to September 30, 2001, the average annual outflow from Lake Kissimmee through S-65 was 645,000 acre-feet (ac-ft). During the drought, there were eight consecutive months with no outflow from Lake Kissimmee (November 2000 to June 2001). The total outflow from October 1999 through September 2001 was 701,490 ac-ft, of which only 11,780 ac-ft was for the 12-month period from July 2000 through June 2001. This is the third lowest discharge volume for twelve consecutive months on record.

During the drought, the District tracked groundwater levels in the Upper Floridan aquifer in the Upper Kissimmee Basin in Orange County. This area is adjacent to the city of Orlando, which is a major water user of the Upper Floridan aquifer. During the drought, the water level in the Upper Floridan aquifer dropped below its average level in mid March 2000 and remained at this level through September 30, 2001. The water level in the aquifer briefly approached its normal level in late July 2001, but dropped below thereafter.

Water use declined in Upper Kissimmee Basin during the drought. A modified Phase II set of restrictions was developed for the northern part of the basin in conjunction with the St. Johns River Water Management District (SJRWMD). The modified restrictions allowed watering between 4 p.m. and 10 a.m. for two days per week, and varied from the rest of the District which had water use restricted from 6 a.m. to 10 p.m. for two days per week. The SFWMD rules focused on sinkhole development so that only Floridan aquifer sources were identified for restrictions. As a result of the restrictions, all consumptive use permit holders reported dramatic drops in pumpage. On average, the declines in water use hovered between 20 and 25 percent, which was substantial considering the District's stated objective of a 15-percent reduction.

No long-term environmental impacts of drought were observed in the Upper Kissimmee Basin, although water levels in the Upper Chain of Lakes were between 0.5–1.0 ft below regulation schedules. However, impediments to navigation as a result of low water levels during the drought were encountered. Continuous discharge from Lake Kissimmee to the Kissimmee River for environmental restoration was reestablished in June 2001. As a result, numerous initial positive responses were documented within the river/floodplain ecosystem.

LAKE ISTOKPOGA / INDIAN PRAIRIE BASIN

Drought conditions in the Lake Istokpoga and Indian Prairie Basin were severe. Lake Istokpoga fluctuated between 39.6 and 35.9 ft NGVD, with the minimum occurring on June 19, 2001. Based on flow data from January 1, 1972 to September 30, 2001, the average annual outflow from Lake Istokpoga through structure S-68 was 192,000 ac-ft. The total outflow from October 1999 through September 2001 was 292,085 ac-ft, of which only 23,813 ac-ft was for the 12-month period from July 2000 through June 2001. The second lowest annual discharge volume of 32,175 ac-ft occurred in 2000.

In February 2001, the Florida Fish and Wildlife Conservation Commission (FWC), in partnership with the District, took advantage of low surface water elevations in Lake Istokpoga to expedite the drawdown of the lake's water level for muck removal. By the time the lake started to refill in June 2001, 1,300 acres, or two-thirds of the perimeter shoreline had been scraped and harvested and 2.4 million cubic yards of material were removed. The Lake Istokpoga drawdown occurred at a crucial point in the drought and provided necessary relief to permitted users in the basin. Without the additional water from the lake drawdown, the Istokpoga basin could have suffered tremendous losses of both agriculture and livestock. The importance of cooperation and daily communication between permitted users and District staff during this time was evident. Considering the severity of the drought, the number of water use violations encountered was not as high as it could have been. Many violations came from users who did not have a consumptive use permit.

LAKE OKEECHOBEE

The largest component of storage in the SFWMD water management system is Lake Okeechobee, which was greatly impacted by the drought. **Figure 4** depicts the lake's decline in water level during the 2000–2001 drought.

Lake Okeechobee's water level was at or below 11 ft NGVD for only 3 percent of the days from 1931 to 2001; the longest number of consecutive days (194 days) that the lake was below 11.0 ft NGVD was achieved in 2001. The lake's water level declined to 8.97 ft NGVD on May 24, 2001, the lowest water level ever recorded for the lake.

Total available water storage in Lake Okeechobee receded through June 2001 to exceptionally low levels due to releases and evaporation losses. The evaporation loss for the lake was 9.06 ft during the period from October 1, 1999 to September 30, 2001.

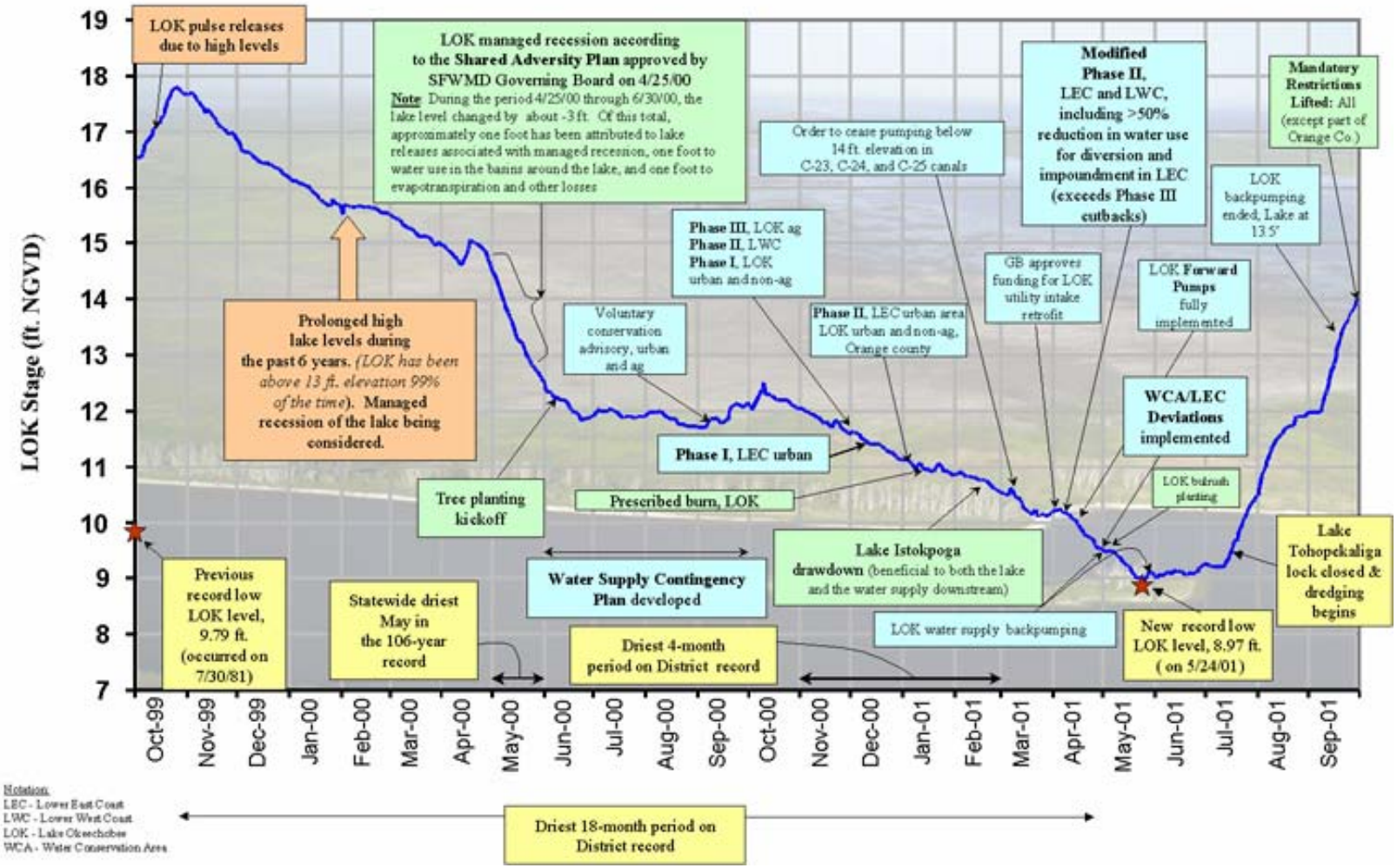

Figure 4. Chronology of the 2000-2001 drought

Figure 5 shows the trend in available storage for Lake Okeechobee from October 1999 to September 2001. In March 2001 as the lake's levels approached 10 ft, fourteen 100-cubic feet per second (cfs) pumps were installed at a total cost of $2.3 million. These pumps were necessary because water could not flow from the lake by gravity at these lower water levels. The pumps operated an average of three days per week and provided needed irrigation to the surrounding farm communities. The pumps were removed in August 2001 after delivering 92,904 ac-ft of water. In June 2001, the lake system began a rapid recovery to near-average seasonal levels by late September 2001.

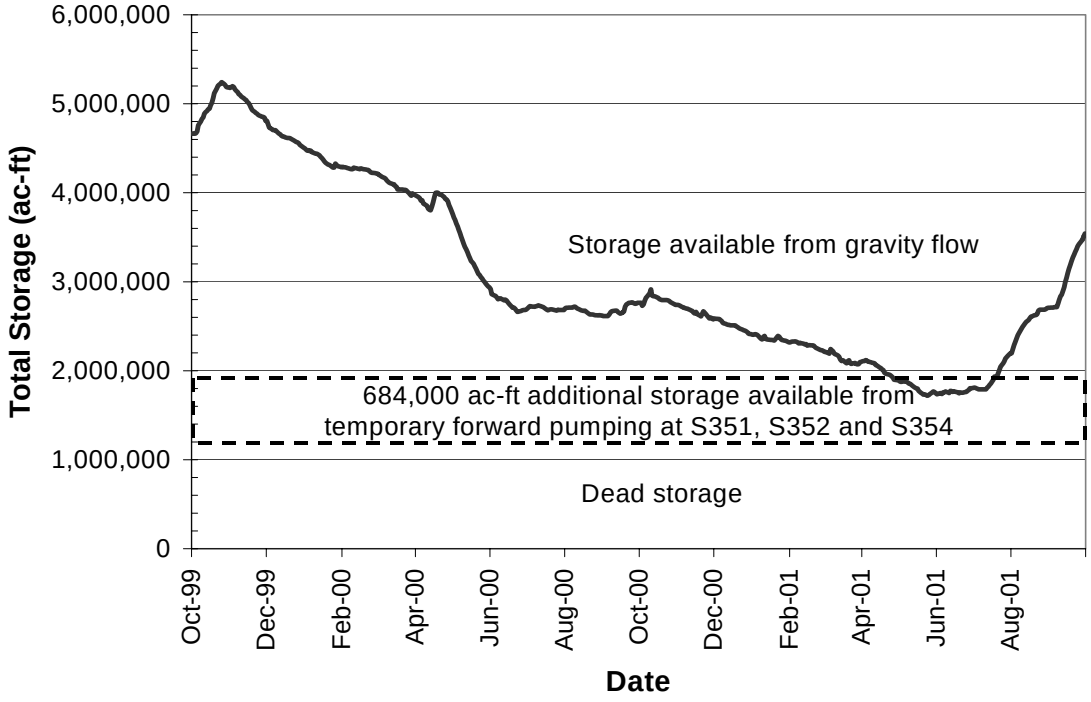

Figure 5. Lake Okeechobee available storage from October 1999–September 2001

The drought's effect on Lake Okeechobee inflows and outflows was significant. From December 1999 to June 2001 there were 19 consecutive monthly inflows below the historical average (**Figure 6**). Based on flows from 1972 to 2001, the average total annual inflow of surface water was 1,999,000 ac-ft, with an annual maximum of 3,520,000 ac-ft during the 1995 El Niño; a minimum annual inflow of 675,000 ac-ft occurred during the 2000–2001 drought.

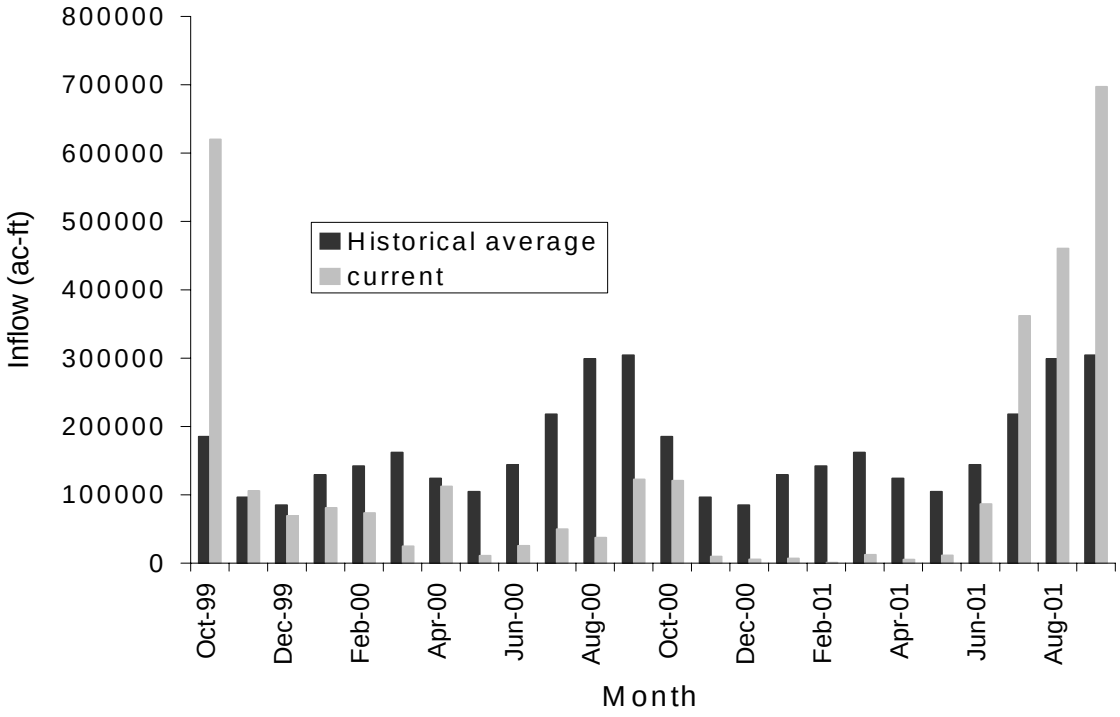

Figure 6. Comparison of historical average and Lake Okeechobee monthly inflows during the drought

Two Emergency Final Orders were issued by the Florida Department of Environmental Protection (FDEP) in April 2001 and August 2001. The first order authorized the District to initiate water supply back pumping into the lake through pump stations S-2 and S-3 at the south end of Lake Okeechobee. The second order allowed the District to continue back pumping and to augment the pumping by gravity flows of water through structures S-4, S-77, S-308, and S-352, and culvert 10-A. During the back pumping period from June 1, 2001 through September 21, 2001, back pumping and augmentation contributed 575,726 ac-ft, or approximately 39 percent of the total inflow to Lake Okeechobee.

Outflows from Lake Okeechobee are mainly to the south; the average historical annual outflow is 1,282,000 ac-ft. The large outflow in May 2000 (**Figure 7**) reflects the water released during the managed lake recession. From October 1999 to September 2001, 16 months of outflows from the lake were below the historical average.

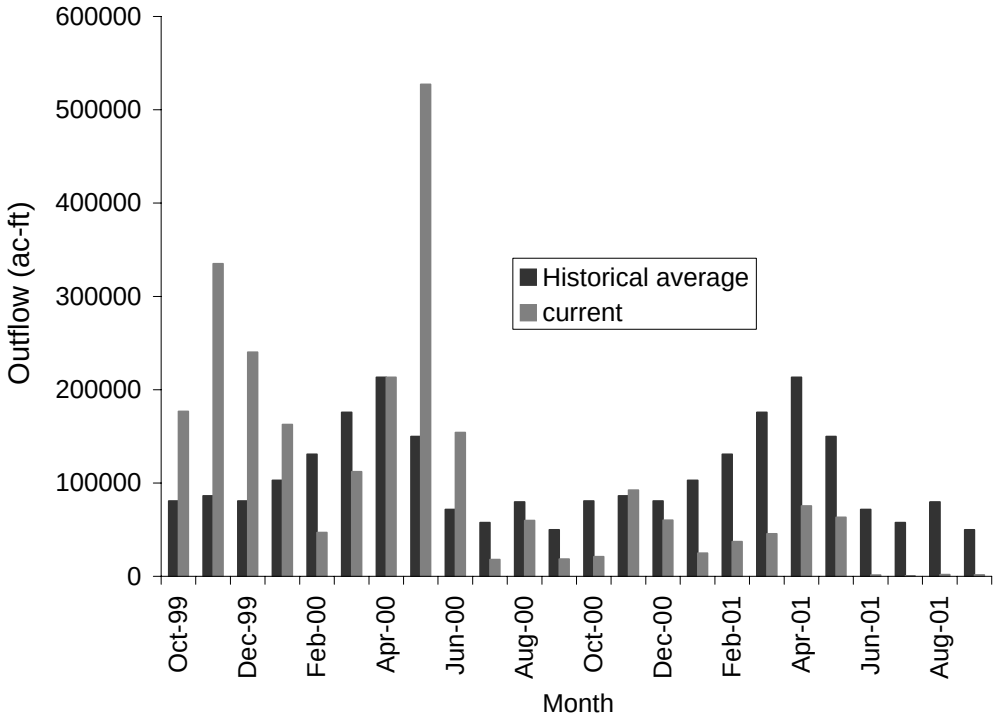

Figure 7. Comparison of historical average and Lake Okeechobee monthly outflows during the drought

Two water supply releases were made from Lake Okeechobee to flush marine chlorides from water supply intakes on the Caloosahatchee River at the Olga water treatment plant. The first occurred as a pulsed release over a five-day period in November 2000 (9,100 ac-ft) and the second release occurred in January 2001 (also about 9,100 ac-ft). Both releases were successful in maintaining water supplies.

The supply-side management (SSM) documentation produced after the 1990–1991 drought provides a scheme for the prudent management of surface water storage in Lake Okeechobee and was used extensively during the 2000–2001 drought. Supply-side management is based upon the concept that the amount of water available for use is a function of the anticipated rainfall, lake evaporation, and water needs for the balance of the dry season in relation to the amount currently in storage. Ten Lake Okeechobee Service Area sub-basins were identified during the SSM implementation in 2000–2001. Allocations for agricultural users in each of these sub-basins were calculated weekly throughout the 45-week period of SSM implementation, which began on November 29, 2000. Throughout this period, SSM calculations were performed weekly on Monday and were posted or communicated to users on Tuesday for implementation on Wednesday.

Lake Okeechobee stage and weekly allocation volumes for the 2000–2001 drought are shown in **Figure 8**. SSM calculations did not explicitly determine lake water allocation for non-agricultural uses, e.g., public water supply to the Lower East Coast Service Areas, releases to navigational lockages, and environmental deliveries to the Stormwater Treatment Areas (STAs). However, the SSM calculations did consider the amount of water consumed by these users in determining lake water allocations for agricultural users within the Lake Okeechobee Service Area. Because drought conditions in June 2001 were expected to be similar to those in May 2001, the methodology associated with dry season SSM was extended through June 2001. A modified method was used from July 2001 through October 2001 based on the South Florida Water Management Model (SFWMM).

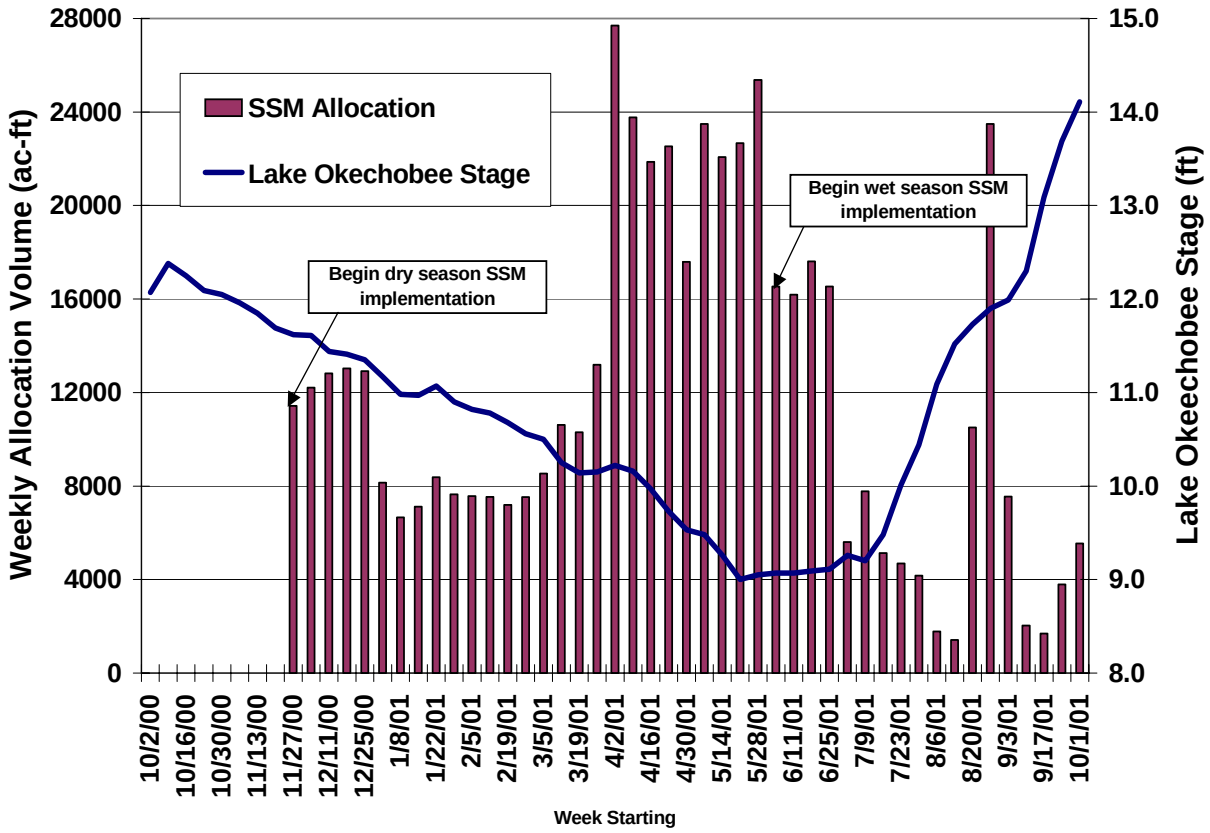

Figure 8. Lake Okeechobee stage and Lake Okeechobee service area allocation during the 2000–2001 drought

The ecology of Lake Okeechobee showed six positive changes in response to the low lake stages, reflecting the ecosystem's recovery after years of damage from high water levels. These included the following:

- Renewed growth of submerged plant beds
- Very clear water in the shoreline regions
- Excellent fishing in the shoreline area
- Widespread oxidation and compaction of organic muck
- Large-scale littoral zone fires that promoted potential re-colonization by native plants
- The opportunity to physically remove an organic berm along the western lakeshore

Another impact to the lake's ecology resulted from a decision to back pump water into Lake Okeechobee. From June 1 through September 21, 2001, back pumping from S-2 and S-3 contributed 22 percent, or approximately 325,000 ac-ft, of the total water inflow into the lake, but only 9 percent, or 37.9 metric tons (mt), of the total phosphorus (TP) contribution to the lake.

One significant negative ecological consequence of the extreme low lake stage was that torpedo grass expansion into native plant communities in the interior littoral zone was more rapid than in earlier years.

The monitoring programs specified by the emergency final orders allowing back pumping and flow augmentation also required additional water quality monitoring of the inflows into the lake for parameters other than nutrients, including pesticides, trace level mercury, and general water quality parameters. Although trace levels of pesticides were found in some samples, no pesticide concentrations exceeded Florida Class I water quality standards. Trace level mercury concentrations at structures associated with back pumping and augmentation of flow to Lake Okeechobee did not exceed the state water quality criterion of 12 nanograms per liter (ng/L) for total mercury. Biological monitoring indicated that there were no negative impacts on submerged aquatic vegetation (SAV) or water transparency from back pumping operations.

STORMWATER TREATMENT AREAS

In general, monthly inflows and outflows to the Stormwater Treatment Areas, located in the Everglades Agricultural Area (EAA), were reduced due to the drought. Efforts were made to prevent treatment cell dryout at Stormwater Treatment Area 1 West (STA-1W) and STA-5. Despite these efforts, both STA-5 and STA-6 did dry out during the most severe period of the drought from December 2000 through May 2001. This event was typical during the dry season for STA-6, but not for STA-5. A temporary pump was placed at STA-5 to keep Cell 1B wet to aid in maintaining the SAV that had been introduced into the cell after STA start-up in 1999–2000.

STA operations during the 2000–2001 drought were based on the philosophy of "shared adversity" with other water users. Due to extreme drought conditions, water levels dropped below the optimal water levels for phosphorus reduction within the STAs and below the minimum operational target of six inches in all the cells, a level typically associated with maintaining a net reduction of phosphorus. The "shared adversity" philosophy was manifested in an operation

strategy designed to supply the minimum amount of water to maintain the vegetation present in the STAs.

Overall, the drought impacts on STA-1W, STA-2, STA-5, and STA-6 were minimal. During the drought, emergency water deliveries totaling approximately 1,600 ac-ft were made to STA-2 Cell 3 and roughly 3,000 ac-ft of water to STA-5 Cell 1B to protect the developing SAV community from drying out.

WATER CONSERVATION AREAS

The Water Conservation Areas (WCAs) are shallow impoundments of remnant Everglades marsh, with a total area of approximately 736,640 acres. Drought impacts to these areas were minimal. For example, the lowest water levels for the WCAs were not observed during the 2000–2001 drought.

Inflows to the WCA-1, WCA-2, and WCA-3 began to decline in October 1999 after Hurricane Irene. There was a brief recovery in April 2000 and again in September and October 2000 as tropical weather systems brought increased rainfall. Significant inflows to all WCAs began again in July 2001 and led to recovery of water levels in all WCAs by late September 2001.

The ability to release water from the WCAs for water supply purposes was severely restricted during 2001. Management of the WCAs and the South Dade Conveyance System (SDCS) during the drought involved operating according to approved schedules. Temporary deviations from approved schedules were obtained to maximize operational flexibility while protecting environmental resources. To a large extent, the successes in obtaining temporary deviations to the minimum water level regulation schedule relied on the timely predictive hydrologic modeling and ecological assessment reports prepared by the District. This information was provided to the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS). These reports revealed no significant ecological impacts due to the temporary deviations.

At WCA-1, water levels fell below the normal minimum water level regulation schedule for approximately four weeks during May 2001. During this time, WCA-1 was operated in accordance with the approved temporary minimum water level regulation schedule (lowering the minimum level from 14.0 to 11.0 ft NGVD). This avoided the need to bring water into this WCA from Lake Okeechobee or other sources while making water supply releases to the Lower East Coast Service Area 1. Rains that began in mid May 2001 returned WCA-1 to non-critical water levels by mid June 2001. Water levels within WCA-2 were already below both the normal and approved lower minimum water level when a temporary deviation was approved in late April 2001. The deviation temporarily lowered the minimum water level from 11.0 to 10.0 ft NGVD. After the rainfall in May 2001, water levels returned to normal in WCA-2 by mid June 2001. The request for a temporary deviation from the regulation schedule for WCA-3 was submitted but subsequently was determined to be unnecessary.

There were a number of excursions from Florida Class III water quality standards in the WCAs during the drought for parameters such as dissolved oxygen (DO), specific conductance, and alkalinity. The majority of these were in proportions no greater than those observed during non-drought years. Of the five parameters with Class III criteria, only DO levels did not comply with the Class III standard in the Everglades National Park (ENP or Park). During the drought, the average total phosphorus concentration at inflow sites was slightly higher than the mean

annual concentrations reported during previous monitoring years. Otherwise, mean nutrient concentrations at other sub-regions of the ENP were similar to those reported previously.

UPPER EAST COAST

The Upper East Coast Planning Area encompasses Martin and St. Lucie counties, as well as the eastern portion of Okeechobee County, and covers approximately 1,200 square miles. The majority of water supply and flood protection in this area is achieved through four major canals. The C-44 basin is connected to Lake Okeechobee while most of the remaining area (C-23, C-24 and C-25 basins) is independent of the lake. As a result, the Upper East Coast was under three different water shortage orders during the drought.

Water users in the C-44 basin were allocated water three times a week, as prescribed under the Lake Okeechobee Supply-side Management Plan. Allocated pumping withdrawals depended on both canal and Lake Okeechobee stages. Ultimately, this planning area did not experience the significant water resource impacts that affected the majority of the District during the drought, primarily because the C-23, C-24, and C-25 basins were independent of the water shortage requirements associated with Lake Okeechobee.

Salinity in both the Caloosahatchee and St. Lucie estuaries increased until mid June 2001. Enhanced water clarity and reduced turbidity accompanied this increase. Although salinity was relatively high in the St. Lucie Estuary, it reached critical levels during the last few weeks of the drought.

The Surficial Aquifer System in the Upper East Coast Planning Area displayed two distinct periods of low water levels. One period occurred from early December 1999 through the end of October 2000. The other occurred between early November 2000 and early August 2001. Because this aquifer system is principally recharged by rainfall, these periods of low groundwater levels occurred during periods of below-normal rainfall.

LOWER EAST COAST

The Lower East Coast (LEC) Planning Area covers approximately 9,000 square miles and includes Palm Beach, Broward, and Miami-Dade counties, as well as portions of Monroe, Hendry, and Collier counties. Land use within the Lower East Coast ranges from urban in the east to undeveloped natural landscapes in the west with significant agricultural areas south of Lake Okeechobee and in southern Miami-Dade County. The area includes significant environmental resources, such as the Everglades ecosystem and Lake Okeechobee, the largest freshwater lake in the southern United States. In addition to the Lower East Coast, the Lake Okeechobee Service Area, which includes parts of Martin, Okeechobee, Glades, and Lee counties, relies on Lake Okeechobee for a portion of its water supply. Highly productive coastal estuaries, such as Biscayne Bay and Florida Bay, exist along the area's shores. Groundwater resources are the principal source of urban water supply for most of the LEC. These resources consist of the Surficial Aquifer System (SAS), which includes the Biscayne aquifer, and the Floridan Aquifer System (FAS). However, areas around Lake Okeechobee rely on the lake as a surface water source for potable water supply.

Two periods of high flow at SFWMD coastal structures in the Miami-Dade area (Lower East Coast, Service Area 3) occurred during the drought. The first was associated with flow from

Hurricane Irene, and the second was caused by an unnamed tropical depression. Otherwise, releases to tide were negligible during the drought.

The Surficial aquifer in Palm Beach County remained below the normal level during most of the drought from early December 1999 through late October 2000, and between early November 2000 and early August 2001. These periods of low groundwater levels occurred during periods of below-normal rainfall.

The Biscayne aquifer is a shallow, unconfined aquifer, which extends from southern Palm Beach County to Miami-Dade County. During dry periods, water stored in the WCAs is released into the District's canals and is used to maintain groundwater levels in the Biscayne aquifer. The water level in the Biscayne aquifer exhibited different trends in different areas during the drought. In northern Broward County, the water level exhibited a trend similar to the SAS in Palm Beach County. There were two periods during which water levels dropped below normal during the drought including from late December 1999 through the end of September 2000, and between early November 2000 and early August 2001. The water level in the Biscayne aquifer in southern Miami-Dade County near the coast generally remained at or above normal levels through the 2000–2001 drought.

As previously noted, Lake Okeechobee experienced extremely low water levels during the drought. A survey of the public water supply utilities that depend on withdrawal of water from the lake indicated that existing intake configurations would not be able to furnish water with Lake Okeechobee levels at or below an elevation of 10 ft NGVD. The District, in coordination with the state of Florida's Emergency Operations Center (EOC), took the engineering, contracting, and construction lead to ensure dependable intake capacity designed for lake levels as low as an elevation of 6 ft NGVD for the cities of Pahokee, Belle Glade, South Bay, Okeechobee, and Clewiston. The purpose of the project was to ensure that utilities using Lake Okeechobee as a surface water source had a continuous and uninterrupted water supply. The total cost for this work was $2.1 million.

A primary concern during the 2000–2001 drought along the Lower East Coast was the threat of saltwater intrusion into water supply wells. Rainfall has been the primary source of recharge for the Biscayne aquifer, but during a drought, seepage from the WCAs and recharge from Lake Okeechobee through canals are important sources of recharge. When the water level in Lake Okeechobee dropped to below 9.2 ft NGVD in May 2001, significant portions of the lake bottom were exposed, and gravity flows to the WCAs and canal system were not possible. Therefore, the District installed pumps that were capable of "forward pumping" water from Lake Okeechobee to the LEC. All flows out of Lake Okeechobee were monitored and compared against the Lake Okeechobee Service Area's weekly allocation. In addition, deliveries were also made to the EAA and WCAs consistent with modified operational schedules.

Pumpage information from selected public water supply wells was also collected and analyzed weekly. Specific wells were selected to monitor saltwater intrusion. Lee County Utilities and Ft. Myers were monitored closely because they were considered "at imminent risk" of saline intrusion into their intake structures due to the inability to release water from Lake Okeechobee to offset salinity coming into the Caloosahatchee River. In addition, utilities that withdrew surface water directly from Lake Okeechobee were considered "at risk" and were closely monitored.

LOWER WEST COAST

The four aquifers in the Lower West Coast (LWC) planning area are combined into two aquifer systems: the Surficial Aquifer System (SAS), consisting of the surficial and lower Tamiami aquifers; and the Intermediate Aquifer System (IAS), consisting of the sandstone and mid-Hawthorn aquifers. The IAS is the main source of potable water in the LWC.

The primary use of groundwater from the Surficial aquifer is agricultural irrigation. During the drought, there were two distinct periods of low water levels in the Surficial aquifer. One period occurred from early January 2000 through early August 2000. The other occurred between mid October 2000 and early August 2001. These periods of low groundwater levels occurred during periods of below-normal rainfall. Between October 1, 1999 and September 30, 2001, there were two distinct periods of declining water levels in the lower Tamiami aquifer. However, the only extended period of time when the water level in the aquifer was below normal was between mid November 1999 and mid April 2000. There were other, shorter periods during the drought when water levels were below normal for the aquifer. However, these periods were not greater than two months.

The Sandstone aquifer is the uppermost aquifer of the IAS. From October 1, 1999 to September 30, 2001, there were two distinct periods of low water levels in the Sandstone aquifer. One period occurred from early January 2000 through mid August 2000. The other occurred between early November 2000 and mid June 2001.

The mid-Hawthorn aquifer is confined and is the lowermost aquifer of the IAS. From October 1, 1999 to September 30, 2001, there were two distinct periods of low water levels in the mid-Hawthorn aquifer. The first period occurred from mid February through mid June 2000. The second occurred between early November 2000 and mid July 2001.

From December 1999 through September 2001, nine counties reported the quantities of water withdrawn for water supply purposes from the aquifers described above. Water restrictions imposed in 2001 were more effective in controlling groundwater withdrawals than those imposed in 2000. Generally, in 2000 the quantity of groundwater withdrawn during the drought was cyclical, i.e., decreasing in one month and then increasing during the next month. Throughout 2001, average daily groundwater withdrawals in each county decreased in each month. The effects of this decrease are noticeable in the semiconfined-to-confined aquifers in the LWC.

On November 29, 2000, the District issued Phase II water restrictions for the LWC and Phase III water restrictions for all uses of the Caloosahatchee River east of the W.P. Franklin Lock and Dam (S-79). By instituting the Phase II restrictions for the surficial, lower Tamiami, sandstone and mid-Hawthorn aquifers, the District was able to help stabilize groundwater levels. This was achieved by limiting groundwater use for irrigation to only two days per week. Salinity in the Caloosahatchee River at Ft. Myers exceeded critical levels from mid November 2000 to mid July 2001.

CHRONOLOGY OF WATER USE RESTRICTIONS

During the 2000–2001 drought, the District imposed Phases II and III mandatory water use restrictions over a large portion of the area under its jurisdiction. Local governments enforced the restrictions on small volume, non-permitted water users, whereas the District enforced restrictions on larger volume, permitted water users. The District also processed variance requests from water users seeking relief from the provisions of the mandatory water use restrictions. **Figure 9** shows the water use restrictions applied to different regions in the District in April 2001.

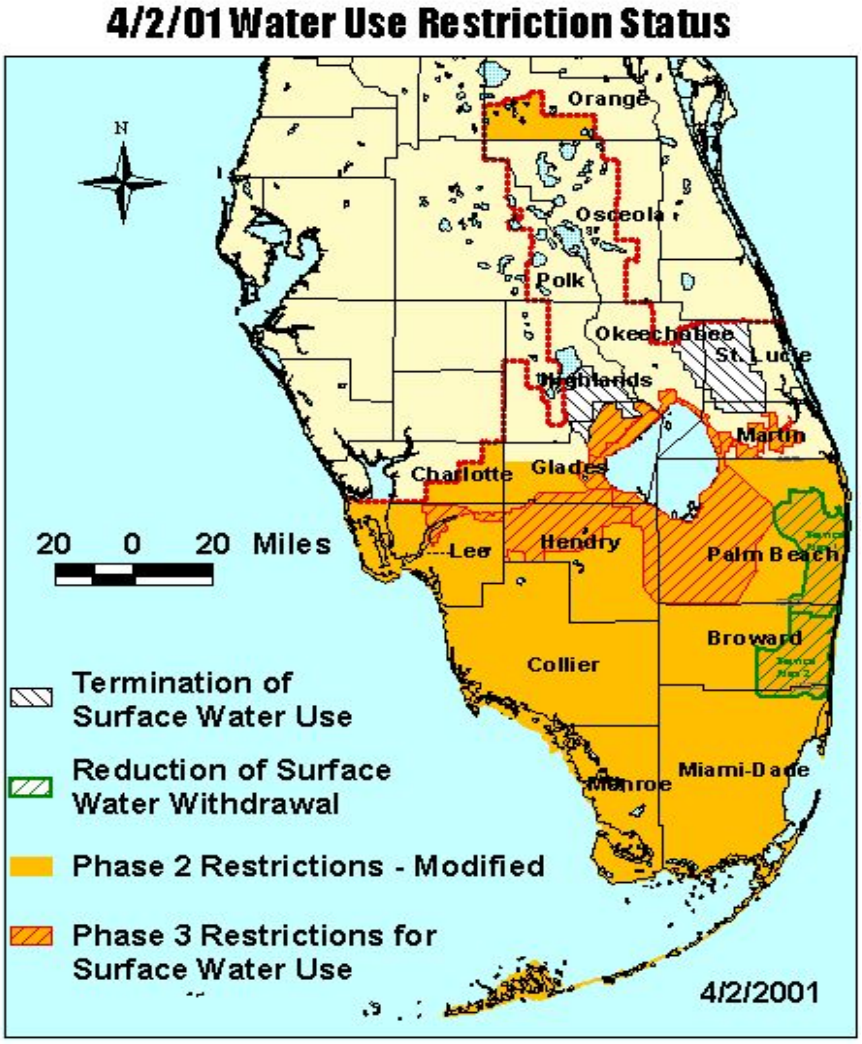

Figure 9. Water use restrictions map, April 2001

A chronological summary of District-related management actions and other drought-related activities are highlighted below.

- On November 29, 2000, the District's Executive Director declared a water shortage emergency for non-agricultural uses from Lake Okeechobee and connected surface waters within the Everglades Agricultural Area water use basin, lake shore perimeter water use basin, Caloosahatchee River water use basin, portions of the Indian Prairie water use basin, and the St. Lucie River water use basin. Phase I water use restrictions were imposed in these areas. A water shortage emergency was also declared for agricultural uses in these same water use basins and Phase III water use restrictions were imposed. Water shortage emergency and Phase II water use restrictions were imposed within the Caloosahatchee River water use basin, Caloosahatchee River watershed North, Caloosahatchee River watershed South, the western-most portion of south Hendry County/L-28 Gap water use basins, the Fakahatchee North water use basin, Fakahatchee South water use basin, the Big Cypress water use basin, and the coastal Collier County water use basin.
- On December 8, 2000, Phase I water use restrictions were imposed for the South Dade, Everglades National Park, WCA-1, WCA-2, WCA-3, 3, C-51, M Canal, C-18, Loxahatchee River, North Palm Beach County, and Interior Palm Beach County water use basins. The District's Governing Board at its meeting on December 14, 2000 approved these water emergency declarations.
- On January 11, 2001, the District's Governing Board declared a Phase II water shortage for both the Lower East Coast region and water use basins in the EAA, Indian Prairie, St. Lucie River, and Lake Okeechobee area. Modified Phase II restrictions were also imposed in the Orlando metropolitan area based on the threat of sinkhole formation from record low Floridan aquifer levels.
- On March 15, 2001 during the Governing Board meeting, the District's Executive Director asked the board to declare a Phase III water shortage emergency, an action enacted for the first time on "demand management" restrictions. Previous water shortages had included Phase III "supply-side" restrictions on water users taking water directly from Lake Okeechobee. The Governing Board approved a motion to impose Phase III restrictions, but this motion resulted in a strong, negative response from participants. Consequently, the Governing Board directed the District to analyze the economic threat/water-saving relationship and to meet with concerned industries to determine an alternative action.
- On March 21, 2001, a public meeting was conducted with District managers. During this meeting, many citizens voiced concern over the potential economic impact on their businesses and clients relative to the projected water savings in implementing Phase III restrictions.
- On March 27, 2001, protestors showed up at the District's special board meeting and picketers gathered outside the District auditorium. At this meeting, the District presented an alternative plan, which identified a modified Phase II declaration for the Lower East Coast and Lower West Coast regions. This plan met three criteria: (1) reduce economic impact; (2) meet or exceed the water saving potential of the existing Phase III restrictions; and (3) make the alternative restrictions enforceable to encourage compliance.

- In September 2001, the Governing Board voted to rescind restrictions for those public water suppliers using at least 20-percent alternative water supply technologies, including water reuse and aquifer storage and recovery (ASR).
- On October 10, 2001 during the Governing Board meeting, the board voted to rescind all water use restrictions and orders, except for those in place for the Orlando area (coordinating with the St. John's River Water Management District's modified Phase II restrictions, which remained in effect).

The District and the local governments within its jurisdiction shared responsibility for enforcing water shortage restrictions. **Table 1** shows the number of warnings and tickets issued during the water shortage.

Table 1. Number of warnings and tickets issued by county during the water shortage

County	Warnings	Tickets
Broward	7985	2579
Charlotte*	N/R**	N/R**
Collier	778	1498
Glades	N/R**	N/R**
Hendry	N/R**	N/R**
Highlands	N/R**	N/R**
Lee	510	2345
Martin	N/R**	N/R**
Miami-Dade	358	234
Monroe	304	3
Okeechobee	27	0
Orange	393	0
Osceola	N/R**	N/R**
Palm Beach	8268	969
Polk*	N/R**	N/R**
St. Lucie	N/R**	N/R**
Total	**18623**	**7628**

* Part of county within District boundary

** N/R - No Report

To track the effectiveness of utility water conservation programs and water supply delivery reductions during water shortages, the District's Water Supply Department produced monthly utility pumpage reports. The reports were produced the Friday before the next regularly scheduled Governing Board meeting to provide up-to-date information for the monthly Water Shortage Conditions Report presented to the Governing Board.

During the 2000–2001 drought, District staff in West Palm Beach and at the Ft. Myers Service Center reviewed 1,052 variance petitions. The West Palm Beach Service Center received and reviewed 85 percent of the petitions, while the Fort Myers Service Center received and reviewed 15 percent of the petitions. The disposition of these reviews is shown in **Table 2,** located on the following page.

Table 2. Petition breakdown for West Palm Beach and Fort Myers Service Centers

Approved	610
Denied	243
Withdrawn	71
Closed Without Action	128
Total	**1052**

Four of the most common use types for which a variance was requested (community/governmental/commercial landscape, 38 percent; single-family landscape, 29 percent; new landscape, 4 percent; and washing of vehicles and non-pervious surfaces, 11 percent) represented 82 percent of the total number of variance petitions received by the District. Agricultural users seeking relief from the daytime SSM requirements comprised 6 percent of variance requests. Public water supply utilities, represented as 1 percent, requested the enhancement of water main pressure and sought authorization to conduct water main flushing for safety purposes. Four motion picture crews working within the Lower East Coast requested permission to irrigate landscaping and to "slick down" roads for film production (< 1 percent).

EMERGENCY MANAGEMENT

The District's Comprehensive Emergency Management Plan establishes the policies and procedures that the District uses to prepare for, respond to, and recover from any and all emergencies. In September 2000, the water shortage was becoming a threat to agriculture, the environment, and water utilities. Based on these concerns and on the precipitation forecast, the District's Executive Director activated the Emergency Operations Center (EOC). The District's EOC served as the information clearinghouse, event coordination center, records management area, and central working area for the Water Shortage Team, consisting of directors from impacted departments. Key staff members from various departments and with various expertise were organized under the EOC sections of water operations, response, logistics, finance, legal, and public information. Many duties required full-time dedication to the water shortage situation, and regular duties were reassigned within the impacted department. The EOC operated approximately 12 hours per day and remained activated until July 2001.

Daily briefings were conducted for team members and a weekly briefing was held for the executive management group. Weekly situation reports summarizing key actions taken by the District were distributed to the Governing Board, the state of Florida's EOC, the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (FDACS), and the governor of the state of Florida. A weekly action plan for the upcoming operational period was developed during a planning meeting that outlined specific assignments for each section. The District's EOC continuously remained in contact with the state's EOC during the water shortage emergency. The state's EOC continued to monitor the situation and prepared contingency plans for delivery of emergency water supplies in the case that a utility became inoperable. Statewide conference calls were held weekly with other water management districts, the FDEP, the Florida Department of Emergency Management (FDEM), FDACS, and the Federal Emergency Management Agency (FEMA).

OUTREACH AND COMMUNICATIONS

The 2000–2001 drought was a consuming issue for area media covering the District. The team's approach was crucial in organizing and communicating District strategies for handling drought-related issues, water restrictions enforcement, media interest, and public awareness. District staff worked seven days per week to respond to the intense interest that the story generated from all branches of the media, including television and radio stations, newspapers, and magazines. Area media became a valued partner in communicating the District's water conservation message to promote a higher level of awareness and understanding among South Florida's residents. That, in conjunction with a multi-tiered approach to communication, also gave the general public a better understanding of the District and its mission. The Office of Media Relations and the Department of Public Information used a variety of communication tools, including water shortage team meetings; press releases and news briefings; daily media contact; media buys, and media campaigns; fact sheets; a citizen information hotline (phone bank); a water shortage website; and other drought-related public information services. Daily media interest was so intense that the District held daily and weekly media briefings from May 4, 2001 through June 29, 2001. Some of the topics covered during the briefings included the latest Lake Okeechobee water levels, water restrictions enforcement, local government coordination, drought signage, drought publications, water conservation tips, and conservation information. These daily and weekly briefings kept local news reporters interested in covering the story of the drought.

The District's water shortage team also relied on a series of drought-themed campaigns for its radio and television "spots." The campaigns were sequenced according to the severity of the drought. The 2000–2001 drought also provided the District with an opportunity to newly educate many of South Florida's residents who, prior to the drought, was not informed about the District, its mission, and the value of water.

ECONOMIC IMPACTS

Although quantitative data are limited, the drought resulted in significant economic impacts to user groups throughout the District. Public water supply utilities experienced unanticipated revenue losses associated with reduced pumpage, and in some cases, higher production costs resulting from increased use of alternative water sources. Agriculture, plant nurseries, and the landscaping and golf course industries also experienced significant negative economic impacts. Small recreational and tourism businesses surrounding Lake Okeechobee were especially impacted by the drought. The drought emergency also took an unanticipated economic toll on the District. By the end of the fiscal year in September 2001, the District had spent $9.7 million of its unbudgeted funds on drought-related expenditures.

LESSONS LEARNED AND RECOMMENDATIONS

- A minimum of one severe drought can be expected every decade.
- It is essential to routinely monitor the following parameters:
  - rainfall deficit
  - Palmer Drought Severity Index (PSDI)
  - climatic forecasts
  - surface water levels
  - groundwater levels
  - water demand
- It is important to develop a drought monitoring system that will alert water managers and water users to the imminence of drought.
- Establishment of a multidisciplinary team to coordinate drought activities was essential to successful drought management. The team should meet at least once a week to develop a weekly action plan and outline specific assignments.
- Water reservations should be established for deliveries of supplemental water to Stormwater Treatment Areas. This is critical to ensure that the STAs meet their long-term phosphorus targets. There is sufficient flexibility to deliver water to the STAs during drought conditions except for STA-6.
- In the northern Kissimmee basin near Orlando, coordination of water use restrictions with the St. John's River Water Management District minimized public confusion over which District's restrictions applied. Water managers should consider a consolidated enforcement plan in this area prior to enacting restrictions.

- Daily communication between permitted users and District staff was important. In some agricultural areas, this was accomplished through a basin coordinator.
- The shoaling problem at the terminus of the C-40 and C-41 canals should be corrected so that the pumps at G-207 and G-208 can function at lower water levels.
- Provisions should be made to transfer water from the C-24 to the C-23 basin in cooperation with the city of Port St. Lucie.
- Alternate water supplies should be considered for utilities that withdraw water from Lake Okeechobee and along the coastal margin.
- Exploit opportunities for environmental restoration during drought conditions similar to those conducted for Lake Istokpoga and Lake Okeechobee.
- Public input on the nature and implementation of water use restrictions is critical.
- Establishment of the water shortage team, under the auspices of the Emergency Operations Center, can provide a necessary framework for internal and external communications.
- Establish better coordination between the District's Geographic Information System (GIS) experts and graphic designers to provide more timely information.
- The water shortage team should designate a "point person" for simplifying technical and legal issues presented to the media and public. The District should identify its "best experts" to help the media explain and clarify drought-related facts at the drought's onset. These experts can help elevate the public's awareness of drought conditions and the District's overall mission.
- Drought managers should invest in and rely on other methods of communicating with the public other than news media such as direct mail, newspaper inserts, advertisements, special events, web page promotion, billboards, signage, television and radio public service announcements, and joint partnerships with water utilities.
- The District must have an aggressive and involved media relations team in place for future droughts.
- Early coordination among the District, county governments, public utility departments, municipalities, and law enforcement agencies is necessary to prepare an effective media campaign.